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Published in:
Proceedings of the 27th international conference extended abstracts on Human factors in computing systems

Publication date:
2009

Document Version
Publisher's PDF, also known as Version of record

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CHI 2009, April 4 – 9, 2009, Boston, Massachusetts, USA
ACM 978-1-60558-247-4/09/04.

Abstract
This paper investigates if and how a digital, interactive affective mirror induces positive emotions in participants. We study whether the induced affect is repeatable after a fixed interval (Study 1) and how the social presence affects the emotion induction (Study 2). Results show that participants systematically feel more positive after an affective mirror session; this effect is shown to be repeatable, and co-presence of a friend is shown to boost this effect.

Keywords
Affective computing, positive emotions, co-presence, mood induction, presence effect, adaptive interfaces

ACM Classification Keywords
H.5.2 User Interfaces: Evaluation/methodology

Introduction
Affective user interfaces are usually characterized as interfaces that try to recognize, interpret and respond to human emotions [1]. In this paper we take a somewhat different albeit related perspective, and study to what extent interfaces can 'induce' emotions in human users, where we focus on positive emotions [2]. For this purpose, a new, multimodal interface concept has been developed: the Affective Mirror (AM),

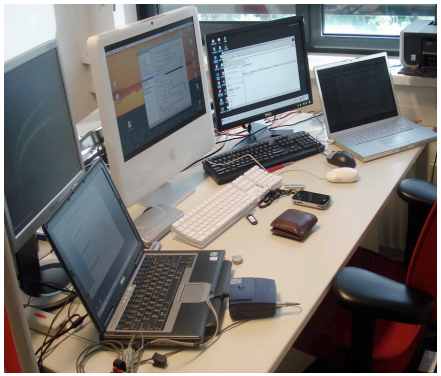

Figure 1. Behind the scenes look at the setting of the Affective Mirror.

which tries to induce positive emotions in users by showing a distorted ("funny") representation of their face. It integrates automatic emotion detection from both face and voice, and uses the fused, perceived emotional state of the user as a "trigger" for selecting different audiovisual effects.

In this paper we report on ongoing evaluation experiments, where we not only aim to test the effectiveness of the AM in inducing positive emotions but also try to gain insight into two specific issues. First, much past experimental work into the expression and detection of mood has been based on studies that consist of single experiments where participants are typically tested once through a specific mood induction procedure [3]. Consequently, it is not immediately clear whether the reported findings of such studies are only temporary, or whether effects on mood may be longer lasting or repeatable. Second, not much is known about possible social factors that may have an influence on the expression of mood [4]. Usually, past experiments in this field are conducted with single participants, even when there are indications that the mere presence of another person may have an effect on the extent to which people show their emotions.

We describe two proof-of-concept experiments, one in which we look at the effect of repeated, individual sessions in front of the AM (Study 1), and one in which we look at the effects of physical co-presence of a friend (Study 2). In both studies, we collect different kinds of data of participants interacting with the AM, including personality information, biophysical measurements, overall user experience measurements and self-reported emotion scores. In this description of work in progress we only report on the latter.

Affective Mirror

The Affective Mirror (AM) is an affective multimodal interface that adapts itself to the user's perceived affective state [5]. The purpose of the AM is to try and make people laugh and thereby induce positive emotions in them. This is done by creating an interactive 'production-perception-adaptation' loop. The basic idea is simple: the AM detects the state of the user and then provides audiovisual feedback by distorting the user's face in the mirror, just like a traditional carnival mirror. The amount and type of face distortions depend on the detected levels of laughter and smiling. The more a participant laughs, the more he/she progresses in different levels of distortions.

Functionality and Architecture

The AM senses the user's state by interpreting the observational user data. The affect sensing system is based on a visual subsystem and a vocal subsystem that detect smiles and laughter. The affect recognition system captures laughter and affective verbal expressions in the voice, and facial expressions from the frontal video stream. Fusion of the recognition subsystems results in monitoring the overall user experience and adapts the AM to the current user state. For details of the components and architecture of the system we refer to [5]. Although the AM[1] is in a stable state, new features have been added, in particular for improving the sensing system. For this study, we added new visual effects, which were synchronized with new audio effects. The dynamic customization of the user interface was also improved, giving the AM a more game-like look. In this study we focus on the use and experimental evaluation of the AM.

[1] The AM was developed in the MultimediaN project.

Figure 2. Individual participant in study 1.

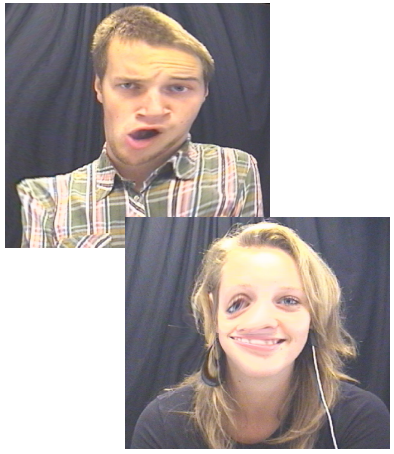

Figure 3. Examples of visual distortions created by the AM.

Study 1: Repeated Exposure

The aim of study 1 is to find out whether users indeed feel more positive after a session with the AM, and whether this effect is repeatable over time. We compare a "natural" condition with a control condition in which participants are asked to suppress laughter.

Participants

Participants were 40 (26 females) Dutch undergraduate students (*M* = 22 years, *SD* = 3.1 years), who participated for course credits. Participants were randomly assigned to an experimental condition.

Procedure

The experiment lasted 70 minutes, and was individually performed. Each experimental session consisted of three parts, where parts 1 and 3 provided the repeated interactions with the AM and part 2 consisted of a controlled "waiting period". Upon arrival in the experimental lab, the participant was seated in a comfortable chair facing the Affective Mirror, which was placed on a small table. At this point the mirror was not active. After seating adjustments, the experimenter introduced himself and briefly described the purpose of the experiment, after which the participant was asked to fill an informed consent form. All participants gave a written consent to record and use audiovisual data for research purposes. After this, the participant filled in a self-report emotion questionnaire ("At this moment, I feel …"), consisting of six 7-point bipolar semantic differential scales with positive and negative adjectives (happy/sad, pleasant/unpleasant, satisfied/unsatisfied, content/discontent, cheerful/sullen, high spirits/low-spirited). The order of the adjectives was randomized; for processing negative adjectives were mapped to 1 and positive ones to 7. Following this, electrodes for measuring galvanic skin response (GSR) and heart rate were attached to the participant and this was followed by a rest period of 5-7 minutes for recording the baseline physiological measurements of the participant. The participant was also fitted with a tie clip microphone for recording the audio required for the AM.

After these pre-session measurements, the experimenter started the actual AM session and left the room. In the "suppress laughter" condition, participants were instructed not to laugh during their interaction with the AM. In the natural, "show laughter" condition, participants received no further instructions except that they simply had to watch the Affective Mirror. Each session lasted 3-5 minutes depending on the amount of detected laughter. As soon as the final level was over, the experimenter entered the room, removed the electrodes and gave the participant the same emotion questionnaire as before. Participants also received a token of appreciation, which consisted of a printed Score Card showing the perceived laughter statistics (amount and duration of recognized laugher from face and voice) together with a funny picture of the participant. Finally, the participant was asked to fill in additional questionnaires about usability and fun of the AM experience, marking the end of the first part.

Next, the experimenter asked the participant to follow him to another room where the controlled waiting period took place, for which the participant was asked to sit in a quite room for 40 minutes. There they were asked to perform various cognitive tasks, which were neither cognitively overloaded nor emotionally sensitive. After this period, the experimenter asked the participant to follow him back to the room where part 1 was conducted. Upon arrival, the participant filled in

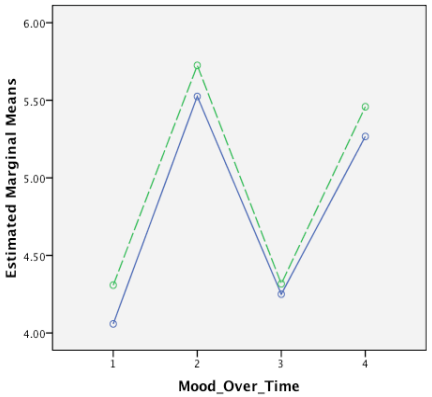

Figure 4. Average self-reported emotion scores as a function of Condition and Time of the emotion measurement.

The blue (bottom) line represents the show laughter condition and green (top) dotted line represents the 'suppress laughter' condition. The x-axis represents the four emotion measurement points and y-axis represents the average self-reported emotion scores on a 7-point scale ranging from 1 (very negative) to 7 (very positive)

the self-report emotion questionnaire again, after which the second session with the AM started, which proceeded in the way described above. After a final filing in of the emotion questionnaire, the participant was debriefed and thanked for the participation.

Statistical Analysis and Design

The experiment had a mixed between-within design, with Time of emotion measurement (4 levels: 1, 2, 3, 4, with 1 and 3 pre-measurements and 2 and 4 post-measurements of the two respective sessions) as within-variable and Condition (2 levels: suppress laughter, show laughter) as between-variable and the self-reported emotion scores as the dependent variable. The internal consistency of the self-reported emotion questionnaire was measured using Cronbach's alpha and was very good ($.83 < \alpha < .92$). Checks for statistical significance were performed with a repeated measures analyses of variance (RMANOVA) where the Bonferonni method was used for making pairwise comparisons.

Results

Figure 4 summarizes the results and reveals a remarkably consistent picture. First of all, it can be seen that participants' self reported emotion scores were not influenced by Condition, $F<1$. Thus, participants report the same emotional state, irrespective of whether they were in the "suppress laughter" or in the "natural" condition. However, the time of the emotion measurement did have a strong, significant effect on the self-reported emotion scores, $F(3,114) = 131.166$, $p < .001$, $\eta^2 = .775$. Inspection of Figure 1 reveals that the first session with the AM worked exactly as intended; participants report more positive feelings after sitting in front of the AM than before (pre-emotion (1): $M = 4.18$, post-emotion (2): $M = 5.63$). Right before the second session with the AM starts, the self-reported emotion scores are back to the initial level (pre-emotion (3): $M = 4.28$), but the second session again works well and afterwards participants report more positive feelings (post-emotion (4): $M = 5.36$). Pairwise comparisons show that measurements 1 - 2 and 3 - 4 differ significantly ($p < .001$), none of the other comparisons is statistically significant. The interaction between Condition and Time of measurement was not significant, $F < 1$.

Conclusion and discussion

Study 1 revealed that the Affective Mirror worked very well in inducing emotions and that participants indeed felt more positive after their AM session. As one would expect, this is a temporary effect, which was essentially over after the 40-minute controlled waiting interval. However, we also discovered that the positive affect induced by the affective mirror is repeatable, in that participants again reported more positive feelings after their second interaction with the Affective Mirror. Interestingly, the results revealed that for the reported emotions it did not matter whether participants were instructed to suppress their laughter or not. In fact, many participants failed to continuously suppress their laughter, which we take as important evidence that the AM indeed makes people laugh.

Study 2: Physical co-presence

The aim of this study was to see whether there is an effect of physical co-presence on the effectiveness of the AM. For this we compared single participants (who sat in front of the AM alone) with participants who sat in front of the AM in the presence of a friend. Again we compared a "natural" and a "suppress laughter" condition.

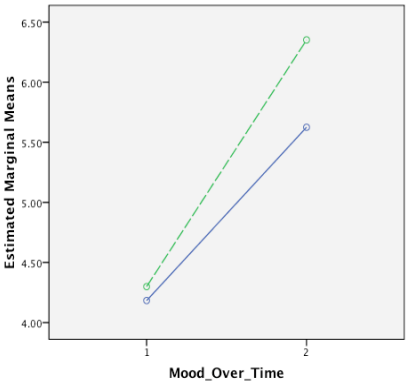

Figure 5. Comparison of the changes in mood across pair and individuals

The blue (bottom) line represents the mood over time for individuals and green (top) dotted line represents the mood over time for pairs. The x-axis represents the two emotion measurement points and y-axis represents the average self-reported emotion scores on a 7-point scale ranging from 1 (very negative) to 7 (very positive)

Participants

Participants were 94 (55 females) Dutch undergraduate students (*M* = 21 years, *SD* = 2.4). Of these, 54 participated in self-selected pairs, consisting of friends. Pairs were randomly assigned to either a suppress (*N* = 14) or a natural condition (*N* = 13). The 40 individuals were those of Study 1.

Procedure

The procedure of study 2 was essentially the same to that of study 1. This allowed us to re-use data from the individual participants of study 1 of their first session with the AM. In the case of pairs of participants, it was first decided which participant would sit in front of the AM first. The other participant sat on the left side of the participant in front of the AM, such that the friend's face and the distortions of the affective mirror could be seen. After this session, which proceeded exactly as described for study 1 (including measurements and questionnaires), the two participants switched seating positions, and another session with the AM was initiated in exactly the same way. At the end, both participants were debriefed and thanked for their participation.

Statistical Analysis and Design

The internal consistency of the self-reported emotion questionnaire was measured using Cronbach's alpha and was again very good ($.82 < \alpha < .93$). Two separate analyses were run. First we analysed the data from the pairs in a mixed between-within design, with Time of emotion measurement (2 levels: pre and post) as within-variable and Condition (2 levels: supress laughther, show laughter) and Turn (2 levels: first, second) as between variables. Next we compared the data from individuals and pairs in a comparable mixed between-within design, with Time of emotion measurement as within-variable, and Co-presence (2 levels: alone or together) as between-variables and the self-reported emotion scores as the dependent variable. Checks for statistical significance were performed with repeated measures analyses of variance (RMANOVAs).

Results

Analysis of the pairs' data revealed that there was no significant effect of Condition nor of Turn (both $F<1$). These two factors do not interact with any of the other factors. In other words, for the self-reported emotion scores it does not matter whether participants from pairs sat in front of the mirror first or second. In addition, as in study 1, it does not matter whether participants were asked to suppress their laughter or not. Based on these results, we aggregated the data of all participants across Condition and Turn for further analysis. Figure 5 summarizes the results for the comparison between pairs and individuals. It can clearly be seen that participants report overall more positive scores *after* their session with the AM (M = 6.36) than before (M = 4.29), F (1,92) = 957.170, $p < .001$, $\eta^2 = .912$). Interestingly, this effect is stronger for participants who participated with a friend than for single participants, cf. the significant interaction between Time of the emotion measurement and co-presence, F (1,92) = 29.249, $p < .001$, $\eta^2 = .241$.

Conclusion and discussion

In general, the analysis of the self-reported emotion scores in study 2 confirm the findings of study 1: the affective mirror succeeds in inducing positive emotions in participants, irrespective of whether they are in the "natural" condition or in the "suppress laughter" condition. In addition, this study showed that the effect is stronger for people who participate with the AM with

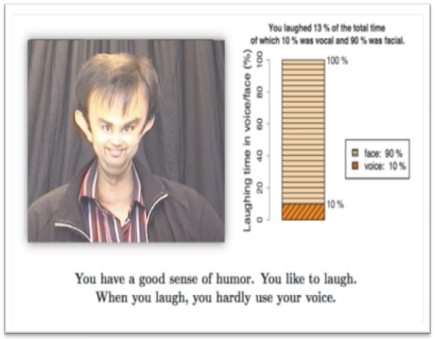

Figure 6. Scorecard: presented as a token of appreciation

a friend present, suggesting that social factors strengthen the effectiveness the AM. These results are consistent with the results found by [6], namely, doing an activity together with a friend results in feeling better than doing an activity alone. These results also strengthen the results of other studies [7, 8] where the effect of the social presence on game players was investigated and it was revealed that the game experience and emotional response increases in the physical presence of a friend.

Conclusions and Ongoing Work

The Affective Mirror is a novel interface concept for inducing emotions in users in a natural and ethical way. The AM creates a game-like situation and adapts itself intelligently based on the user's perceived current affective state. Two explorative experimental evaluation studies reveal that participants indeed report more positive feelings after a session in front of the AM, where study 1 revealed that this effect is repeatable and study 2 that it is stronger in a social setting with a friend present. Interestingly, in both studies it did not matter whether participants were instructed to suppress their laughter of whether they were not instructed about laughter at all. The fact that participants cannot suppress their laughter even when instructed not to do so strongly suggests that participants find the AM truly funny.

This work is ongoing and there are many avenues for future research. Firstly, we will further analyze the collected data, where we will be looking for correlations with biophysical and personality data with the self-reported emotion scores reported in this paper. Secondly, we aim to strengthen the AM's affect recognition system where it would be interesting to feed the biophysical data into the AM feedback loop. Thirdly, we want to use the collected video-clips for perception studies (analyzing participants' facial expressions) where we are particularly interested in differences between the "suppress" and the "natural" condition. Finally, we are running more studies under the social dimension, to investigate how the presence of a stranger or of a person with incongruent behaviour effects the expression of emotions.

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